

Thermodynamics

①



a $2.50 \text{ g But} \times \frac{1 \text{ mol But}}{88 \text{ g But}} = 0.0284 \text{ mol Butyric Acid} - 60.0 \text{ kJ}$
 $0.0284 \text{ mol Butyr} : \boxed{2110 \text{ kJ/mol}}$



c $\Delta G^\circ = -2110 \text{ kJ} - \left[(25^\circ + 273) \left(-117.3 \frac{\text{J}}{\text{mol K}} \right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}} \right) \right] = \boxed{-2075 \text{ kJ}}$

$\Delta S^\circ = \left[4(213.6 \frac{\text{J}}{\text{mol K}}) + 4(69.91 \frac{\text{J}}{\text{mol K}}) \right] - \left[1(226.3 \frac{\text{J}}{\text{mol K}}) + 5(205.0 \frac{\text{J}}{\text{mol K}}) \right] = \boxed{-117.3 \frac{\text{J}}{\text{mol K}}}$

d $\Delta G = -RT \ln K$

$\frac{\left(-2110 \frac{\text{kJ}}{\text{mol}} \right) \left(\frac{1000 \text{ J}}{1 \text{ kJ}} \right)}{- \left(8.31 \frac{\text{J}}{\text{mol K}} \right) (25 + 273)} = \ln K = 837$
 $\boxed{K = e^{837}}$

e $5.00 \text{ g But} \times \frac{1 \text{ mol But}}{88 \text{ g But}} \times \frac{-2110 \text{ kJ}}{\text{mol But}} = \frac{+120.0 \text{ kJ}}{(30.0^\circ - 25.0^\circ)} = \boxed{24.0 \frac{\text{kJ}}{^\circ \text{C}}}$
 sign lost b/c heat given off by Rxn = heat absorbed
 By bomb so sign changes

f $\frac{120}{-240 \text{ kJ lost}} = \frac{120}{240 \text{ kJ}} = 1.912 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{4.184 \text{ J}}{(^\circ \text{C})} \times \frac{1 \text{ kJ}}{1000 \text{ J}} \times (T_f - 25^\circ \text{C}) + \frac{\text{heat gain by cool H}_2\text{O}}{\text{heat by cal}} \left(\frac{24.0 \text{ kJ}}{^\circ \text{C}} (T_f - 25^\circ \text{C}) \right)$

$T_f = 28.8^\circ \text{C}$

$$g \quad -2110 \frac{\text{kJ}}{\text{mol}} = \left[4(-393.5 \frac{\text{kJ}}{\text{mol}}) + 4(0 - 285.85 \frac{\text{kJ}}{\text{mol}}) \right] - \left[1(\Delta H_{f,B}) + 5(0 \text{ kJ}) \right]$$

$$\boxed{\Delta H_f = -607.4 \frac{\text{kJ}}{\text{mol}}}$$



$$i \quad \Delta S_f^\circ = 226.3 \frac{\text{J}}{\text{mol K}} - \left[4(5.69 \frac{\text{J}}{\text{mol K}}) + 4(130.6 \frac{\text{J}}{\text{mol K}}) + (205.0 \frac{\text{J}}{\text{mol K}}) \right] = -523.9 \frac{\text{J}}{\text{mol K}}$$

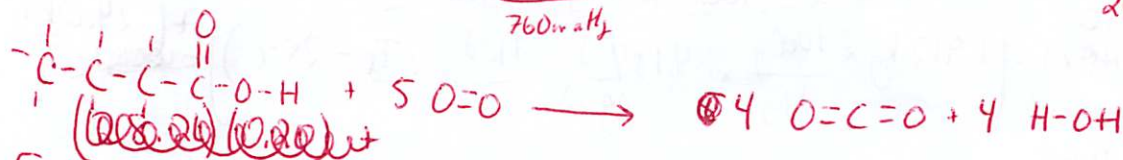
$$j \quad \Delta G = 607.4 \frac{\text{kJ}}{\text{mol}} - (25^\circ + 273)(-523.9 \frac{\text{J}}{\text{mol K}}) \left(\frac{1 \text{ kJ}}{1000 \text{ J}} \right) = -451.3 \frac{\text{kJ}}{\text{mol}}$$

$$k \quad \Delta H_f \text{H}_2\text{O}(g) > \Delta H_f \text{H}_2\text{O}(l)$$

b/c $\text{H}_2\text{O}(g)$ is higher in Energy than $\text{H}_2\text{O}(l)$ b/c E needed to vaporize the $\text{H}_2\text{O}(l)$

$$l \quad 20.0 \text{ g But} \times \frac{1 \text{ mol But}}{88.0 \text{ g But}} \times \frac{5 \text{ mol O}_2}{1 \text{ mol But}} = 1.14 \text{ mol O}_2$$

$$V = \frac{(1.14 \text{ mol})(0.08206 \frac{\text{L atm}}{\text{mol K}})(25 + 273)}{\frac{750 \text{ mm Hg}}{760 \text{ mm Hg}}} = 28.2 \text{ L O}_2 \times \frac{100 \text{ L air}}{20 \text{ L O}_2} = \boxed{141 \text{ L air}}$$



$$m \quad \left[3(377 \text{ kJ}) + 4(414 \text{ kJ}) + 1(715 \text{ kJ}) + 1(360 \text{ kJ}) + 1(464 \text{ kJ}) + 5(0) \right] - \left[8(715 \text{ kJ}) + 8(464 \text{ kJ}) \right] = -2110 \text{ kJ}$$

$$5478 \text{ kJ} + 5(0) - 9432 \text{ kJ} = -2110 \text{ kJ}$$

$$(0=0) = \boxed{379 \text{ kJ}}$$

2a $\Delta H > 0$ b/c $H_2O(g)$ is greater in Potential Energy than $H_2O(l)$ so since the process (2)

is endothermic ΔH is greater than 0.

$\Delta S > 0$ b/c $H_2O(g)$ has more disorder thus higher Entropy than $H_2O(l)$ so

ΔS is greater than 0.

$\Delta G < 0$ B/c this process happens spontaneously ΔG must be less than 0.

$\Delta T < 0$ B/c endothermic processes decrease T

b $\Delta H > 0$ b/c the temperature of the mixture decreases thus the process is endothermic and $\Delta H > 0$

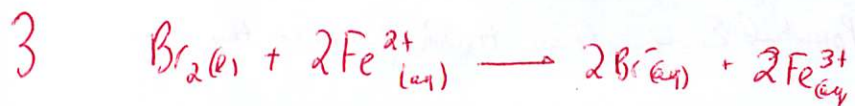
$\Delta S > 0$ b/c the ionic solid dissociates ($NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$) in H_2O .

These ions are free to move around thus have more disorder than the solid.

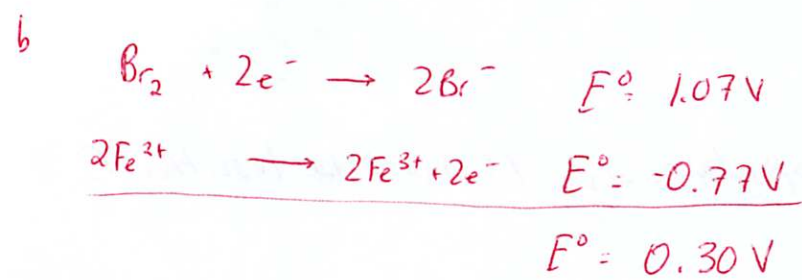
$\Delta G < 0$ B/c the process is spontaneous thus the ΔG must be less than 0

c As $T \uparrow$ solubility will \uparrow in the process E is absorbed as NH_4Cl dissolves.

Therefore if more energy is added more NH_4Cl will dissolve. (The endothermic process is favored as $T \uparrow$)



$$a \quad \Delta S = \left(2 \left(82.0 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) + 2 \left(-293.3 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) \right) - \left(1 \left(245.2 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) + 2 \left(-113.4 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) \right) = \boxed{-441.0 \frac{\text{J}}{\text{mol} \cdot \text{K}}}$$



$$\Delta G = -n F E^{\circ} = -(2) \left(96500 \frac{\text{C}}{\text{mol} e^{-}} \right) (0.30 \frac{\text{J}}{\text{C}}) \times \frac{1 \text{ kJ}}{1000 \text{ J}} = \boxed{-57.9 \text{ kJ}}_{\text{mol}}$$

$$c \quad \Delta G = \Delta H - T \Delta S$$

$$-57.9 \frac{\text{kJ}}{\text{mol}} = \Delta H - (25^{\circ}\text{C} + 273) \left(-441.0 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}} \right)$$

$$\boxed{\Delta H = -189 \text{ kJ}}$$

$$d \quad \Delta G = -RT \ln K$$

$$- \left(57.9 \frac{\text{kJ}}{\text{mol}} \times \frac{1000 \text{ J}}{1 \text{ kJ}} \right) = - \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) (25^{\circ}\text{C} + 273) \ln K$$

$$\ln K = 23.4$$

$$\boxed{K = 1.41 \times 10^{10}}$$

$$e \quad \text{yes since } \Delta S \text{ is } (-) \text{ and } \Delta H \text{ is } (-) \text{ when you } \text{plug them into } \Delta G = \Delta H - T \Delta S$$

@ High T, TΔS is + and larger than ΔH so this will make ΔG + and Rxn nonspontaneous.

$$f \quad E = E^{\circ} - \frac{0.059}{2} \log \frac{[\text{Br}^{-}]^2 [\text{Fe}^{3+}]^2}{[\text{Fe}^{2+}]^2} \quad \text{since } \text{Br}_2(l) \text{ is not in the Q Expression it will not affect cell voltage}$$

g all [] would decrease but numerator raised to 4th power will be smaller than denominator to 2nd so $Q < 1$ and E will increase